# RFA–1 FM RF AMPLIFIER

Belar Electronics Laboratory, Inc.
P.O. Box 826
Lancaster Avenue at Dorset
Devon, Pennsylvania 19333

## SECTION 1

# GENERAL INFORMATION

## 1–1 GENERAL DESCRIPTION

The Belar RFA–1 FM RF amplifier is a sensitive, high gain, all silicon, solid state amplifier designed to meet the requirements of the broadcaster for off-air monitoring of both monaural and multiplexed FM transmitters in the 88–108 MHz band.

The RFA–1 utilizes an I.F. of 10.7 MHz with a phase linear bandwidth of 600 KHz to insure low distortion of a multiplexed signal. The I.F. skirt selectivity is such that an adjacent channel 800 kHz removed is 50 dB down.

## 1–2 PHYSICAL DESCRIPTION

The RFA–1, Figure (00-00) is constructed on a standard 3 x 19 inch rack mount. The RELATIVE OUTPUT meter and POWER push button are located on the front panel. The AC power input, RF input and output, and the POWER ADJUST Control are located on the rear of the unit as shown in Figure (00-0).

The RFA–1 is completely solid state utilizing all silicon transistors and integrated circuits for long, trouble-free life. The individual circuits are constructed on military grade, glass epoxy, plated printed circuit boards. High reliability industrial and military grade components are used throughout.

## 1-3 ELECTRICAL DESCRIPTION

The RFA–1 is a solid state, sensitive, high gain RF amplifier consisting of an RF preamp, a balanced mixer, a 10.7 MHz I.F. strip, a balanced modulator, an RF postamp, and a crystal oscillator. It utilizes a 10.7 MHz I.F. in order to obtain the required adjacent channel rejection. In addition the I.F. has a wide phase linear bandwidth of 600 KHz in order not to degrade high frequency stereo separation.

The dynamic range of the amplifier is such that no adjustments are necessary over an input range of 100 uV to over 0.5 V. (approx. 70 dB).

A POWER ADJUST control is provided that will vary the output level from approximately .2 to 1 W. A front panel meter indicates the relative RF output level. Although the amplifier is primarily designed to drive the Belar FMM–1 monitor, the available output level is sufficient to drive any currently available monitor.

## 1–4 ELECTRICAL SPECIFICATIONS

| | |
|---|---|
| RF Input Sensitivity | 100 uV for full output |
| Antenna Impedance | 50–75 ohm |
| Phase Linear Bandwidth | 600 KHz |
| Adjacent Channel Rejection (800 KHz removed) | 50 dB |
| Dynamic Range | 100 uV to 0.5V (70 dB) |
| Image Rejection | greater than 60 dB |
| I.F. Rejection | greater than 90 dB |
| L.O. Radiation | Meets Applicable FCC Spec. |
| RF Power Output | 1 W. |
| Output Impedance | 50 ohm |
| Power Consumption | 5 W. |

## 1–5 MECHANICAL SPECIFICATIONS

| | |
|---|---|
| Dimensions | 3½ x 19 x 11½ inches overall |
| Detailed Dimensions | Figure 00-0 |
| Net Weight | 00lbs. |
| Shipping Weight | 00lbs. |

## 1–6 INSTRUMENT IDENTIFICATION

The instrument is identified by the model number and a six digit serial number. The model number and serial number appear on a plate located on the rear panel, Figure 0-0. All correspondence to your Belar representative or to the Belar factory in regard to the instrument should reference the model number and complete serial number.

## 1–7 ACCESSORIES

A Yagi antenna (Belar ) cut to frequency with 00ft. of coax is available as an option.

## SECTION 2

# INSTALLATION

## 2–1 INITIAL INSPECTION

Check the shipping carton for external damage. If the carton exhibits evidence of abuse in handling [holes, broken corners, etc.], ask the carrier's agent to be present when the unit is unpacked. Carefully unpack the unit to avoid damaging the equipment through use of careless procedures. Inspect all equipment for physical damage immediately after unpacking. Bent or broken parts, dents

and scratches should be noted. If damage is found, refer to Paragraph 2–2 for the recommended claim procedure. Keep all packing material for proof of damage claim or for possible future use.

## 2–2 CLAIMS

If the unit has been damaged, notify the carrier immediately. File a claim with the carrier or transportation company and advise Belar of such action to arrange the repair or replacement of the unit without waiting for a claim to be settled with the carrier.

## 2–3 REPACKING FOR SHIPMENT

If the unit is to be returned to Belar, attach a tag to it showing owner and owner's address. A description of the service required should be included on the tag. The original shipping carton and packaging materials should be used for reshipment. If they are not available or reusable, the unit should be repackaged in the following manner:

a. Use a double-walled carton with a minimum test strength of 275 pounds.

b. Use heavy paper or sheets of cardboard to protect all surfaces.

c. Use at least 4 inches of tightly packed, industry approved, shock absorbing material such as extra firm polyurethane foam or rubberized hair. NEWSPAPER IS NOT SUFFICIENT FOR CUSHIONING MATERIAL.

d. Use heavy duty shipping tape to secure the outside of the carton.

e. Use large FRAGILE labels on each surface.

f. Return the unit, freight prepaid, via air freight. Be sure to insure the unit for full value.

## 2–4 PREPARATION FOR USE

The RFA–1 RF Amplifier is designed to be mounted in a standard 19" rack mount. The unit should be mounted either immediately below or above the FMM–1 monitor. This is so the RF output cable may be kept as short as possible and dressed away from the RF input cable. When the unit is mounted above high heat generation equipment, such as vacuum tube power supplies, consideration should be given to cooling requirements which allow free movement of cooler air around the RFA–1. In no instance should the ambient chassis temperature be allowed to exceed 50 C (122 F). Mount the RFA–1 to the rack mount using four No. 10 screws and four No. 10 countersunk finishing washers.

The RFA–1 requires a 105 to 125 VAC single phase, 50–60 Hz power source. Consult Belar for operation with other power sources. Connect a 50 ohm coaxial cable [RG-58/U] between the RF output connector, J2, at the rear of the chassis and the RF input connector of the monitor. Connect the antenna cable to the RF input connector, J3, at the rear of the chassis.

# SECTION 3

# OPERATION

## 3–1 INITIAL OPERATION

The following procedures should be followed for placing the unit into initial operation. Refer to Figure 3–1 for control locations.

1. Turn the POWER ADJUST control fully counterclockwise.

2. Depress POWER push button. Button will light indicating power on.

3. Turn POWER ADJUST control clockwise. Note that RELATIVE OUTPUT meter moves upscale.

NOTE: DO NOT OPERATE THE RFA–1 FOR PROLONGED PERIODS WITHOUT A 50 ohm LOAD CONNECTED TO J2. TO DO SO WILL CAUSE EXCESSIVE DISSIPATION AND POSSIBLE FAILURE OF THE OUTPUT TRANSISTOR.

## 3–2 NORMAL OPERATION

For normal operation, leave the POWER ADJUST control turned down to the minimum output necessary to reliably operate the monitoring equipment.

Because of the large dynamic range of the amplifier, no other controls are necessary. The amplifier limits at 100 uV and any signal above this level will insure proper operation.

# SECTION 4

# PRINCIPLES OF OPERATION

## 4–1 BLOCK DIAGRAM DESCRIPTION

Figure 4–1 is a block diagram of the RFA–1.

The incoming RF signal is applied to the RF preamp, A1Q1, where it is amplified and applied to the Balanced mixer, A1IC1. Here the signal is mixed with the output of the crystal oscillator, A2Q1, which is 10.7 MHz above the signal frequency. The 10.7 MHz signal which results is then applied to the I.F. strip consisting of A1T1, A3IC1, A3T1, A3IC2 and A3T2. The I.F. output along with the buffered local oscillator signal from A2Q2 is applied to the Balanced Ring Modulator consisting of A3T3, A3T4, and A3CR1 thru A3CR4. The output of the Balanced Modulator is a DSB suppressed carrier signal in which the lower sideband is the original RF carrier frequency. Since the same local oscillator is used to down-convert and up-convert, any frequency error in the local oscillator will cancel. Therefore, the LSB will be exactly the same as the input RF carrier frequency. However, the local oscillator must be stable enough to keep the signal centered in the I.F. passband to prevent non-linear phase distortion. The DSB signal from the Balanced Modulator is applied to the LSB filter amplifier consisting of A3Q1, A3L1 & A3L2. This amplifier passes the LSB while rejecting the residual carrier and USB. The output of the LSB filter is then applied to driver A4Q1 and power amplifier A4Q2 which raises the level to the required 1 W. output. The RELATIVE OUTPUT meter indicates the relative RF power level.

The Power supply provides unregulated plus and minus 20 VDC to the A2 and A4 Cards and Zener regulated plus and minus 6.2 VDC to the A1 and A3 Cards.

## 4–2 DETAILED CIRCUIT DESCRIPTION

### 4–2–1 A1 CARD - RF PREAMP AND BALANCED MIXER

The incoming RF is applied to the emitter of A1Q1 through the tuned circuit consisting of A1L1, A1C1 & A1C2. The signal is amplified by A1Q1 and applied in push-pull to the inputs (pins 1&7) of balanced mixer A1IC1 through the two mutually coupled tuned circuits A1L2, A1C3 & A1L3, A1C4. The balanced mixer is used because of its greatly reduced susceptibility to spurious responses. The three tuned circuits ahead of the mixer contribute more than 60 dB image rejection to the amplifier. The local oscillator signal is brought into the mixer on pin 3. The output of the mixer is applied to the first I.F. transformer A1T1 which is tuned to 10.7 MHz.

### 4–2–2 A2 Card – Crystal Oscillator and Buffer

Transistor A2Q1 and associated circuitry form a crystal overtone oscillator that operates directly 10.7 MHz above the RF carrier (98.7–118.7 MHz). This is to reduce the possibility of spurious responses caused by multiplication. Tuned circuit A2L1, A2C1 forces the crystal to operate in the proper overtone mode. The low level oscillator signal to the balanced mixer on the A1 card is obtained by tapping down on the oscillator tank coil A2L1. Transistor A2Q2 and associated circuitry form a buffer amplifier. The output of this circuit is a high level (1 V. across 30 ohm) signal to drive the balanced ring modulator on the A3 card.

### 4–2–3 A3 Card - I.F. Amp, Balanced Ring Mod, & LSB Filter

The 10.7 MHz I.F. signal from the A1 card is applied to the I.F. strip consisting of A3IC1, A3T1, A3IC2, and A3T2. Since the IC input pins 1 and 7 are both at DC ground, the zero-axis crossing is accurately preserved during limiting. The I.F. transformers are critically coupled (k = 1.0) and have a phase linear bandwidth of 600 KHz. These design features insure that there will be no distortion introduced into the signal regardless of input signal level. The I.F. skirt selectivity is such that an interfering signal 800 KHz removed is 50 dB down. The I.F. output signal is coupled via a link on the output I.F. transformer to the Balanced Ring Modulator consisting of A3T3, A3T4 and A3CR1 thru A3CR4. The high level local oscillator signal is also applied to the Balanced Modulator. The action of a ring modulator is such that it requires both inputs to unbalance the bridge and cause an output. This output is in the form of a double side band suppressed carrier signal. In the RFA–1 the lower sideband (fo–10.7) is the exact frequency as the RF input. Because the same local oscillator is used to down-convert and up-convert, any shift in local oscillator frequency is cancelled.

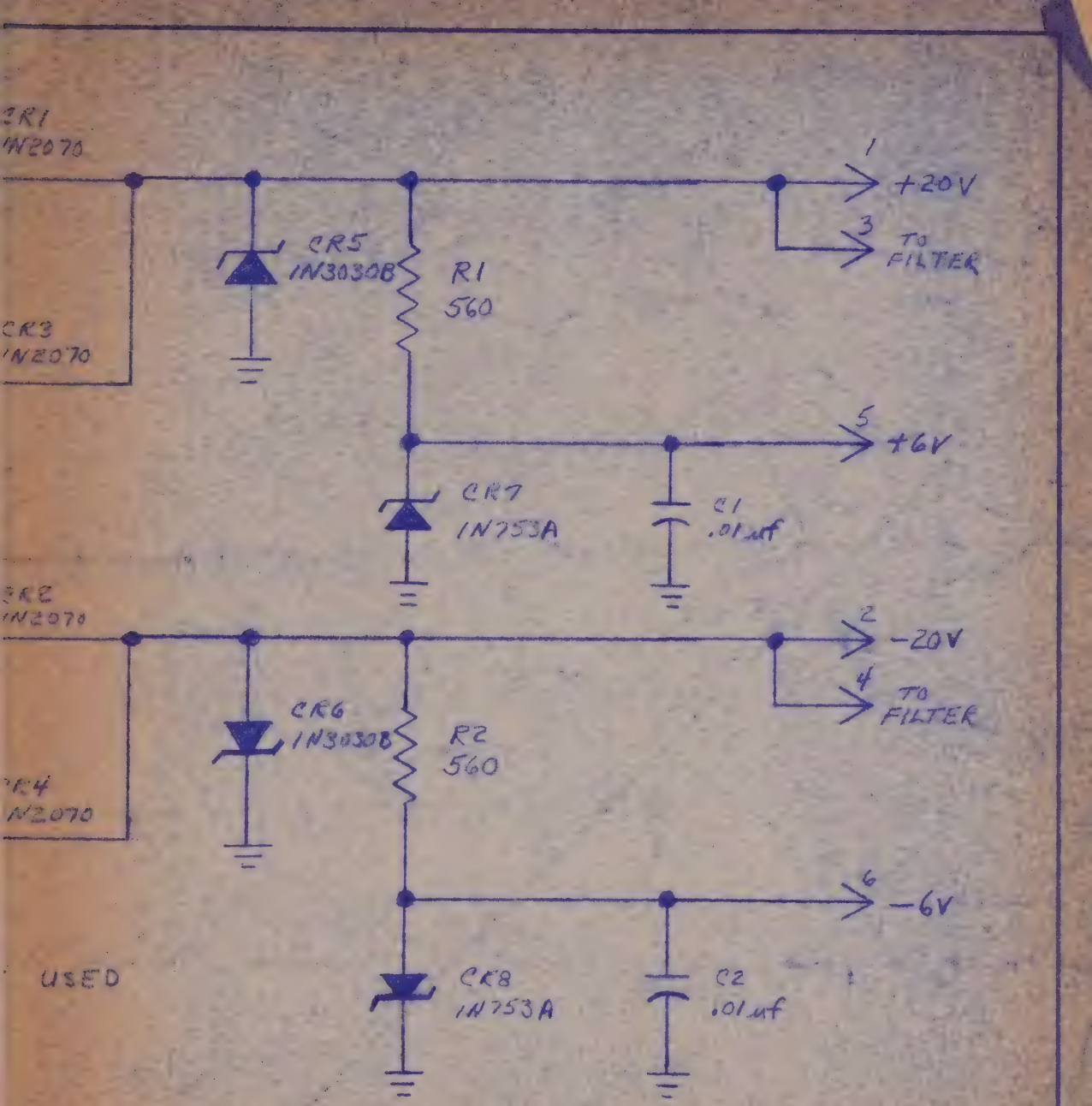
The output of the Balanced Ring Modulator is applied to the base of A3Q1. This transistor and tuned circuits A3L1, A3C11 and A3L3, A3C12, A3C13 form a lower sideband filter which rejects the upper sideband and residual carrier output of the ring modulator.

### A4 CARD – RF DRIVER AND POWER AMPLIFIER

The RF output of the A3 Card is coupled via A4C9 to the emitter of A4Q1. This transistor and associated circuitry form a driver amplifier capable of supplying the power required to drive A4Q2. A4Q2 is a class C power amplifier capable of supplying approximately 1 W. output. A4L3, A4L4, A4C5, and A4C6 provide the tank circuit and the required impedance matching between the load and A4Q2's collector. The collector current for A4Q2 is supplied thru the POWER ADJUST pot located on the rear of the chassis. Diode A4CR1 and associated circuitry form an RF level detector which drives the RELATIVE OUTPUT meter on the front panel.

## A5 CARD – POWER SUPPLY

The POWER supply uses two conventional full wave center-tapped rectifiers. A5CR1 and A5CR3 provide +20VDC and A5CR2 and A5CR4 provide –20 VDC. Filtering is provided by C1 and C2 located on the main chassis. Zener diodes A5CR5 and A5CR6 prevent high level transients that may damage components. A5R1 and A5CR7 form a regulator which supplies +6.2 VDC to the A1 and A3 Cards. A5R2 and A5CR8 form a regulator which supplies –6.2 VDC to the A1 and A3 Cards.

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A5 BOARD (PWR SUP)

RFA-1

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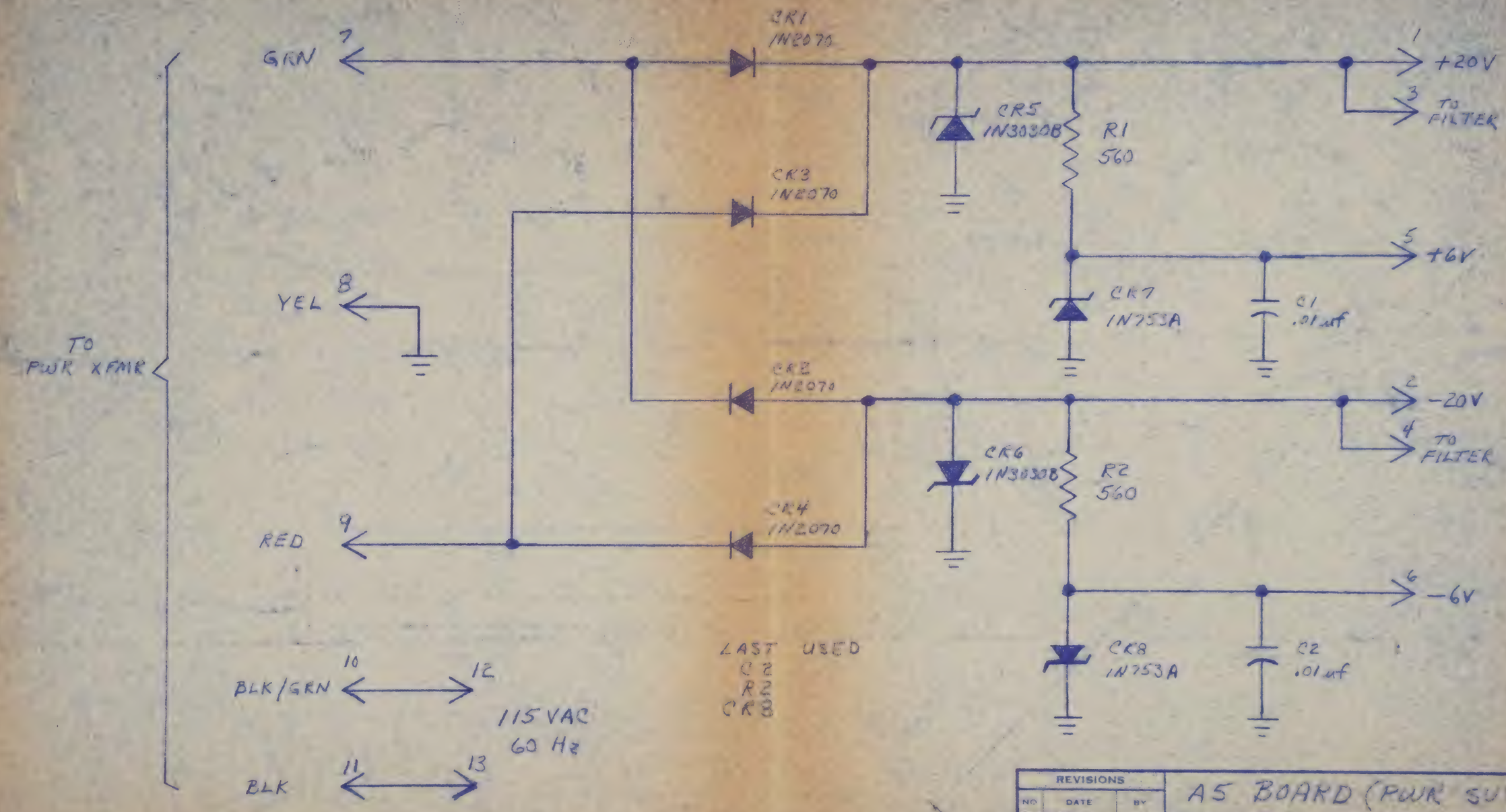


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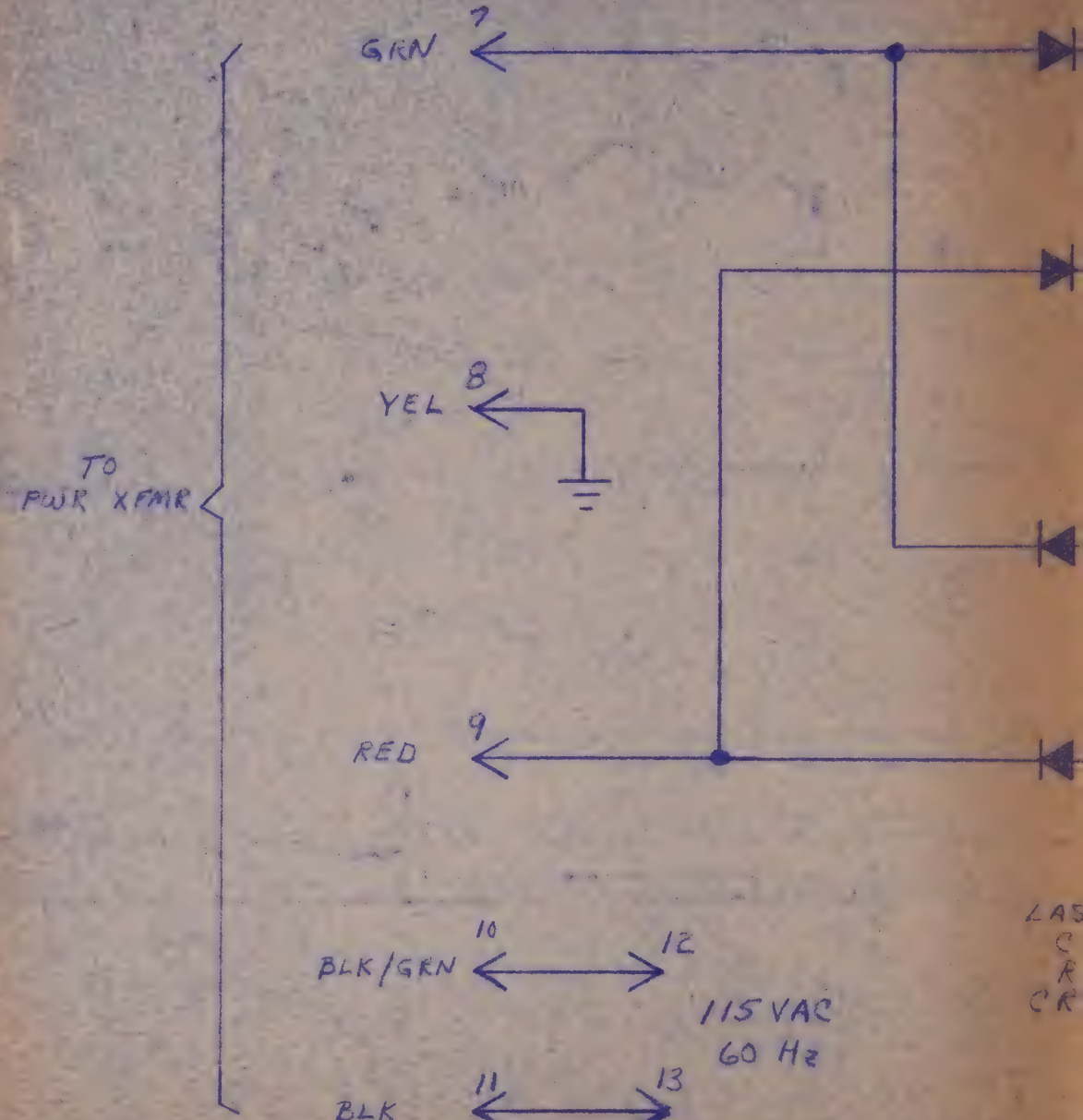
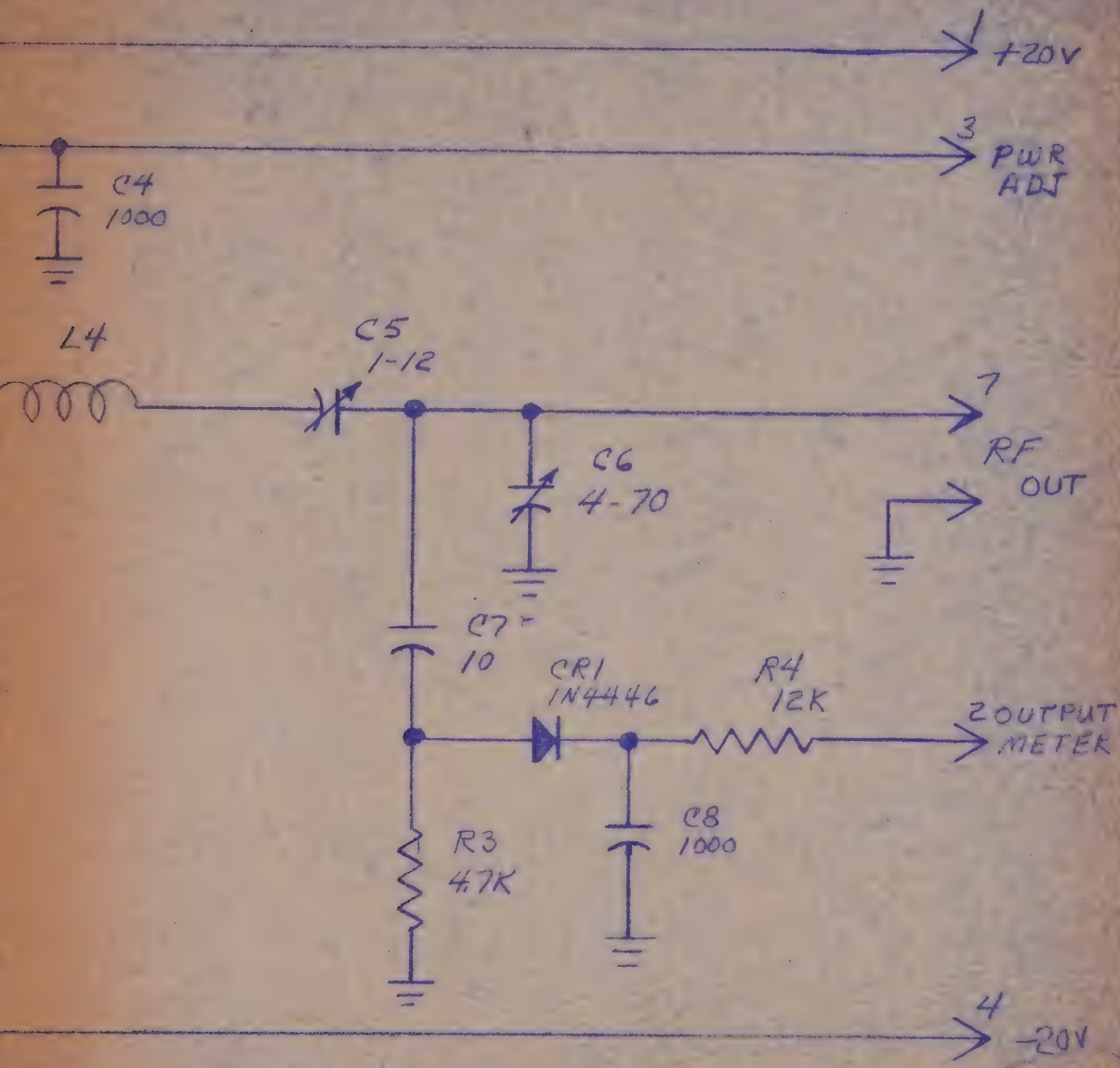

7
GRN
8
YEL
TO
PWR XFMR
9
RED
10
12
BLK/GRN
115 VAC
60 Hz
11
13
BLK
LAS
C
R
CR

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A4 BOARD (RF PWR AMP)

RFA-1

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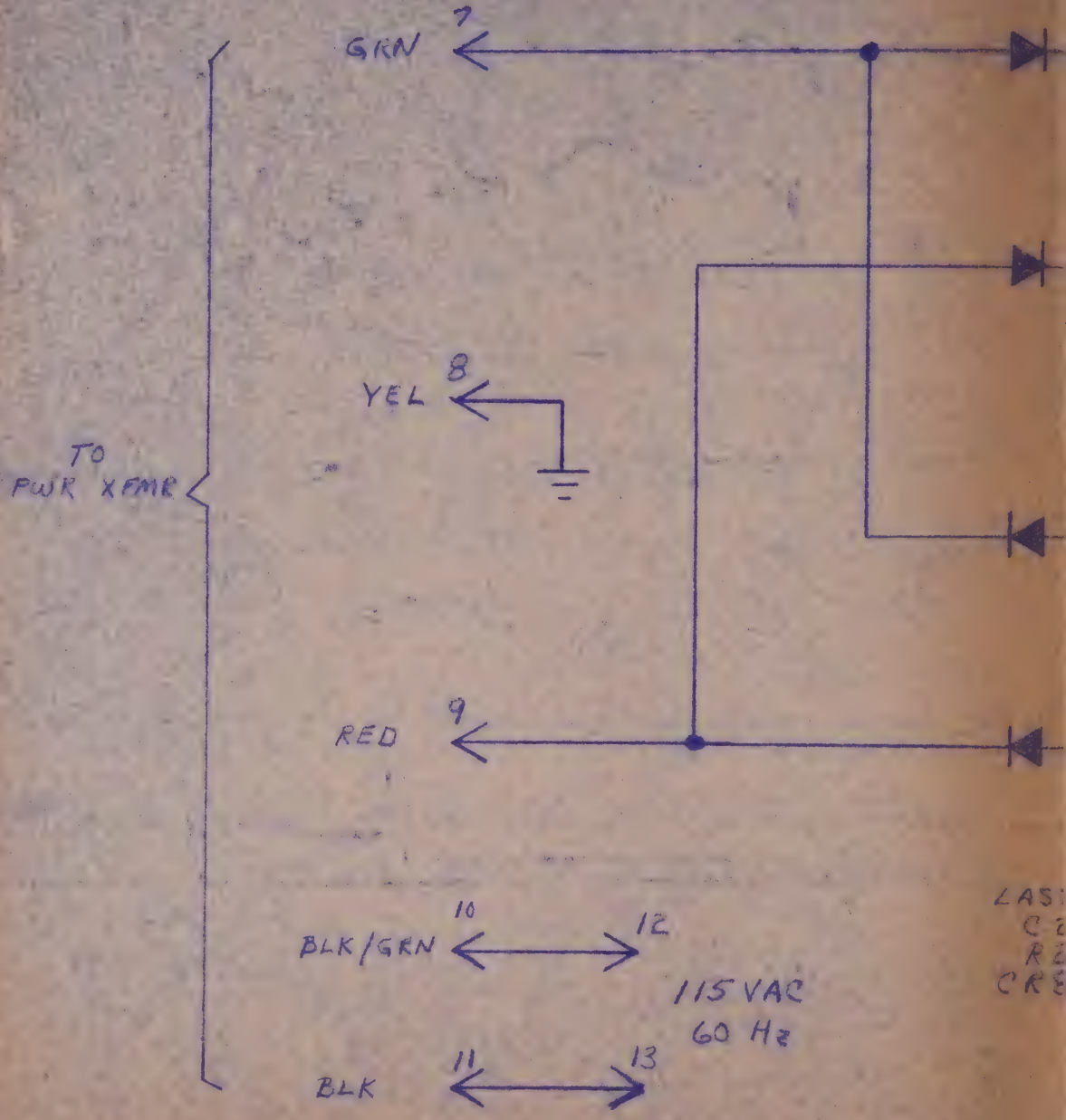
7
GRN
8
YEL
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9
RED
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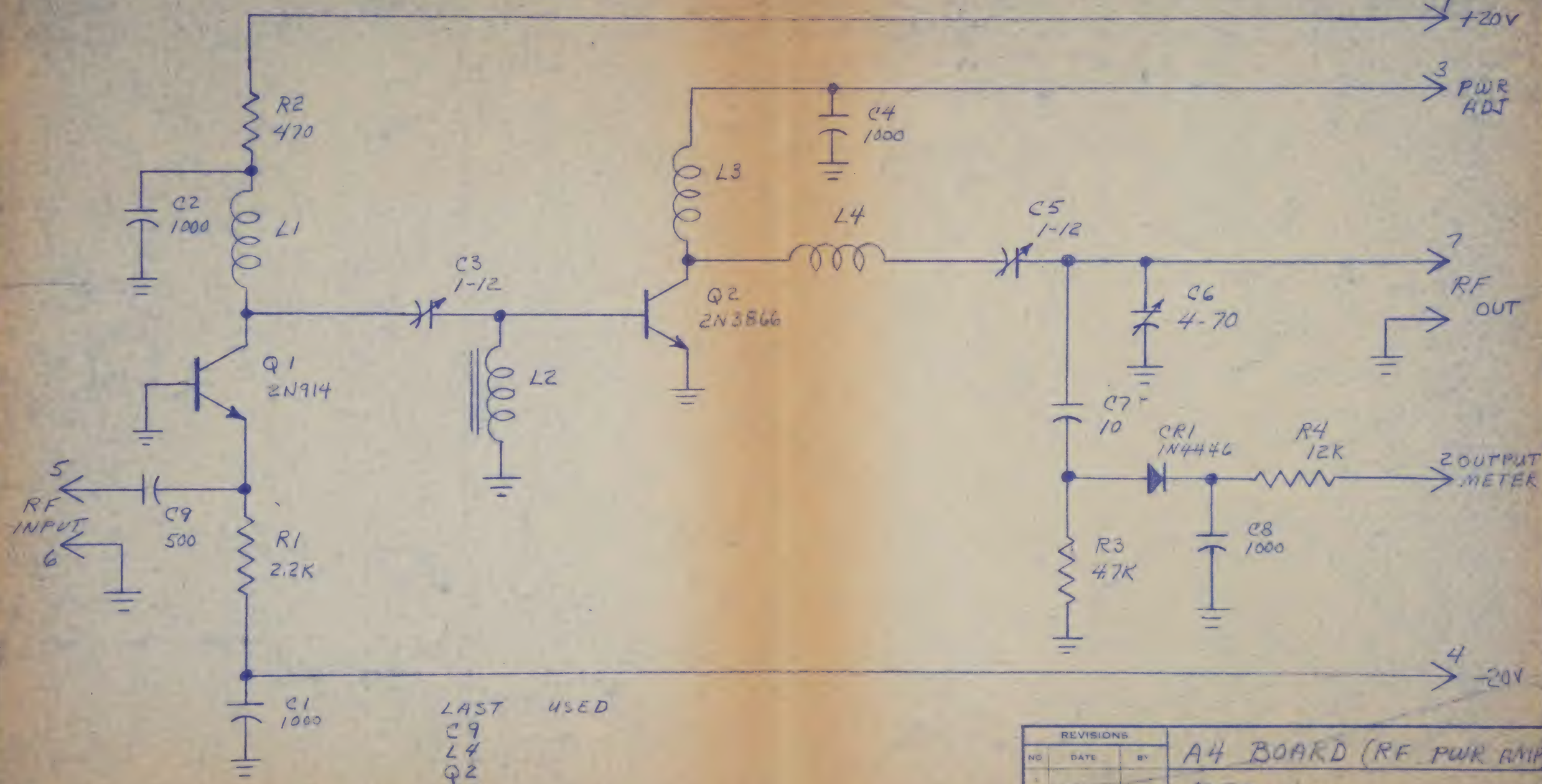
BLK/GRN
12
115 VAC
60 Hz
11
BLK
13




LAST USED
C9
L4
Q2
R4
CR1

ALL CAPACITOR VALUES IN pf

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A4 BOARD (RF PWR AMP)

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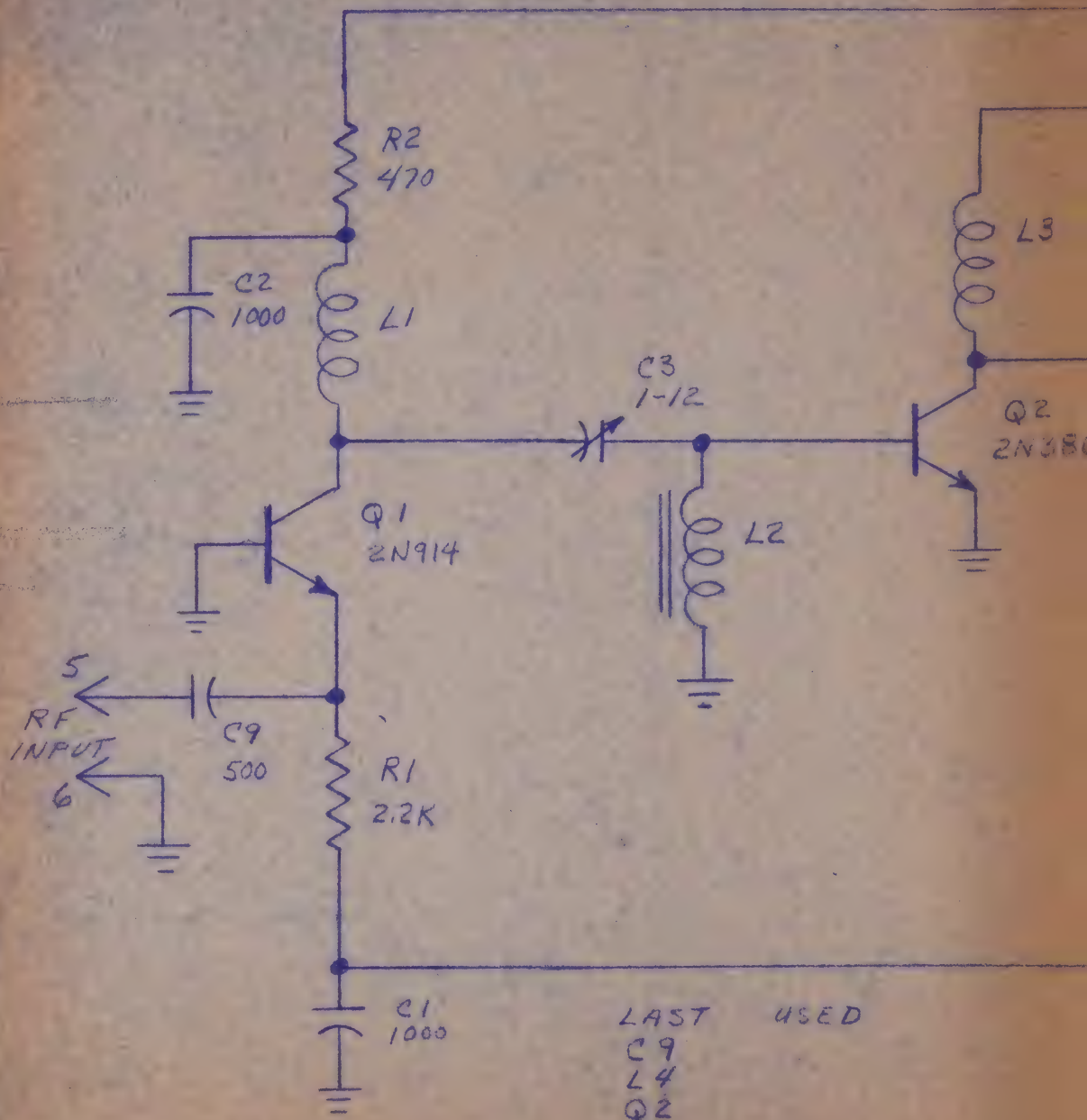


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C9
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Q2
R4
CR1

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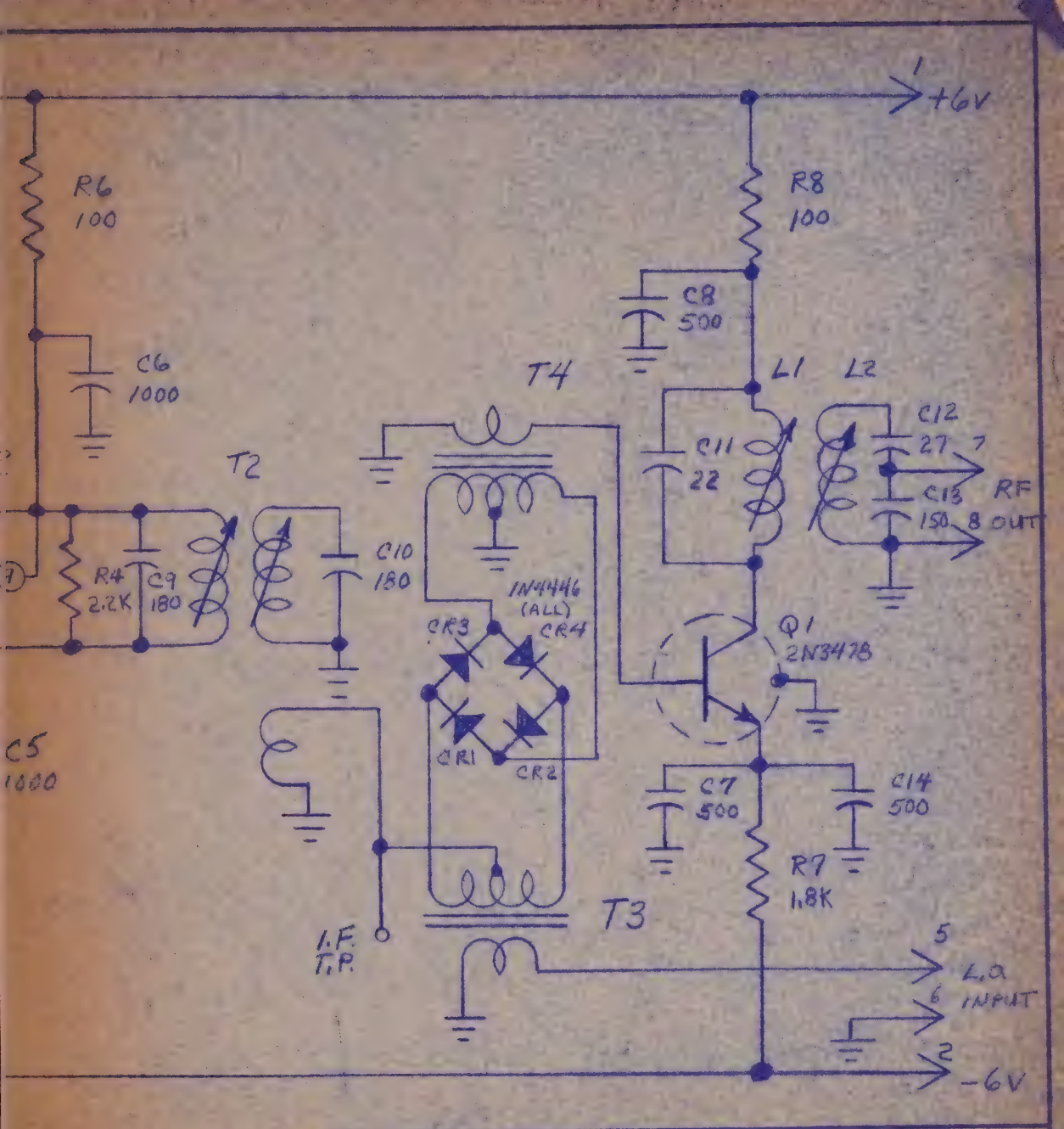


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# A3 BOARD (I.F.)

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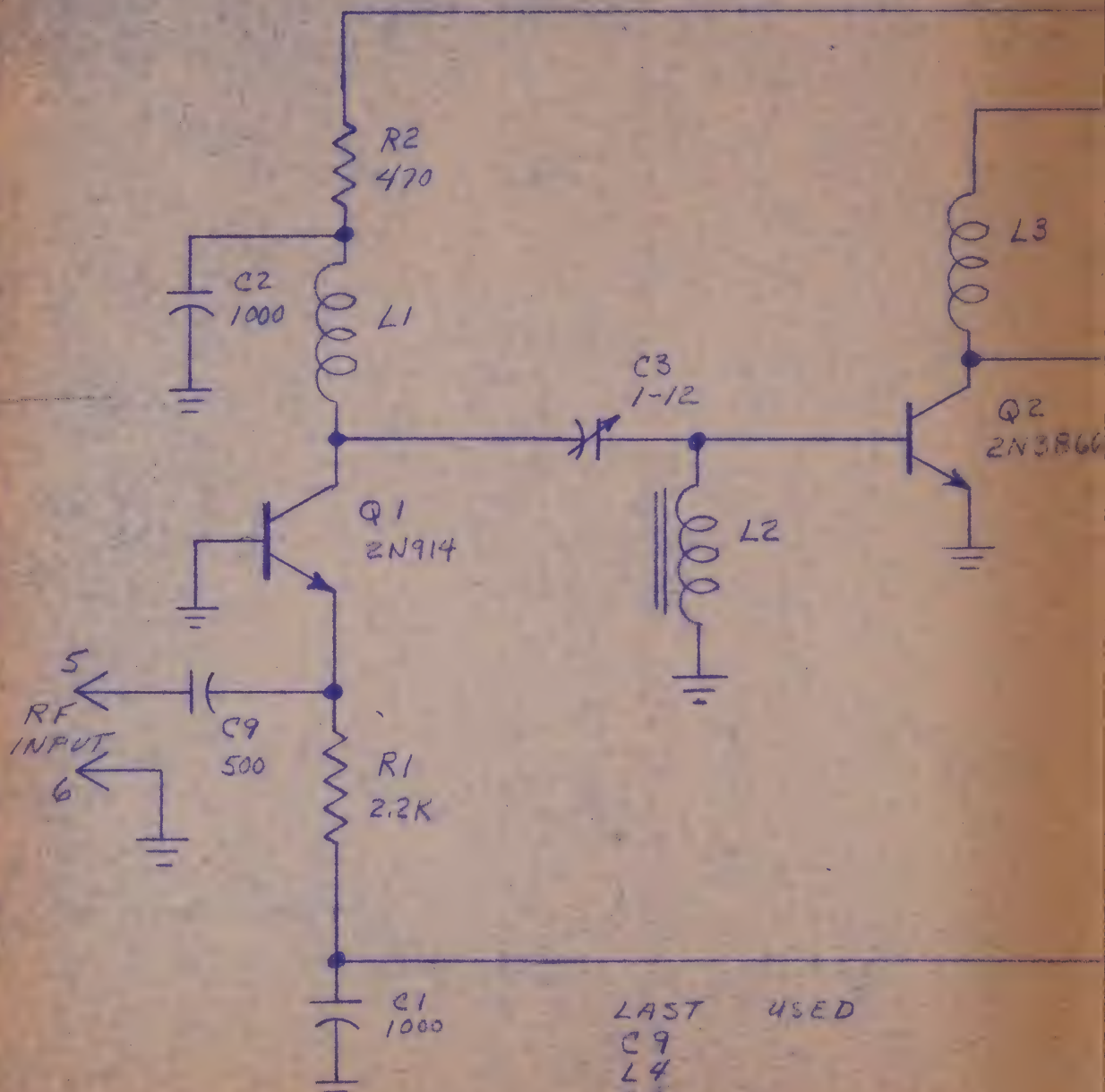


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L4
Q2
R4
CR1

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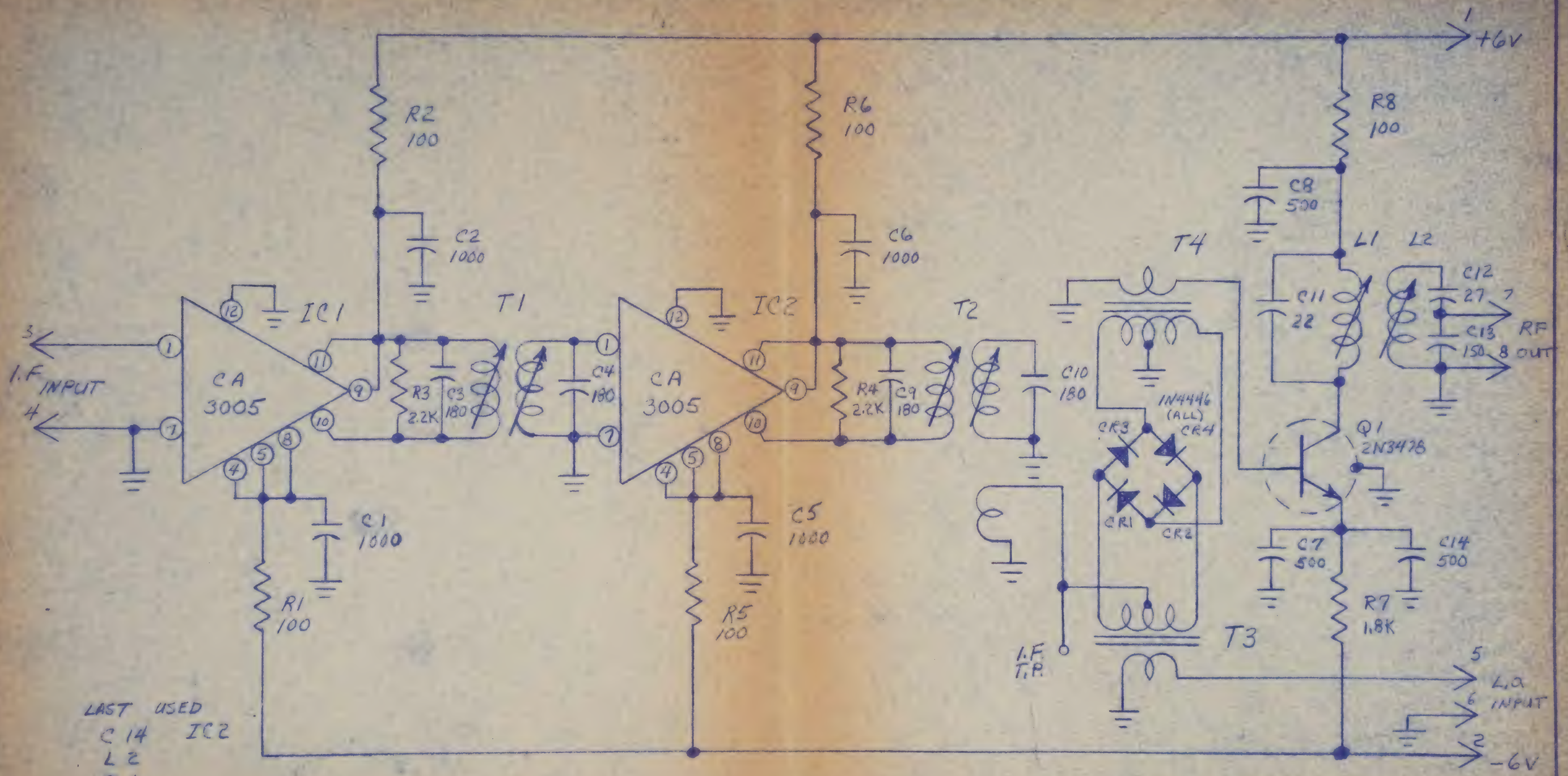


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C 14 IC 2
L 2
Q 1
R 8
T 4
CR 4

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# A3 BOARD (I.F.)

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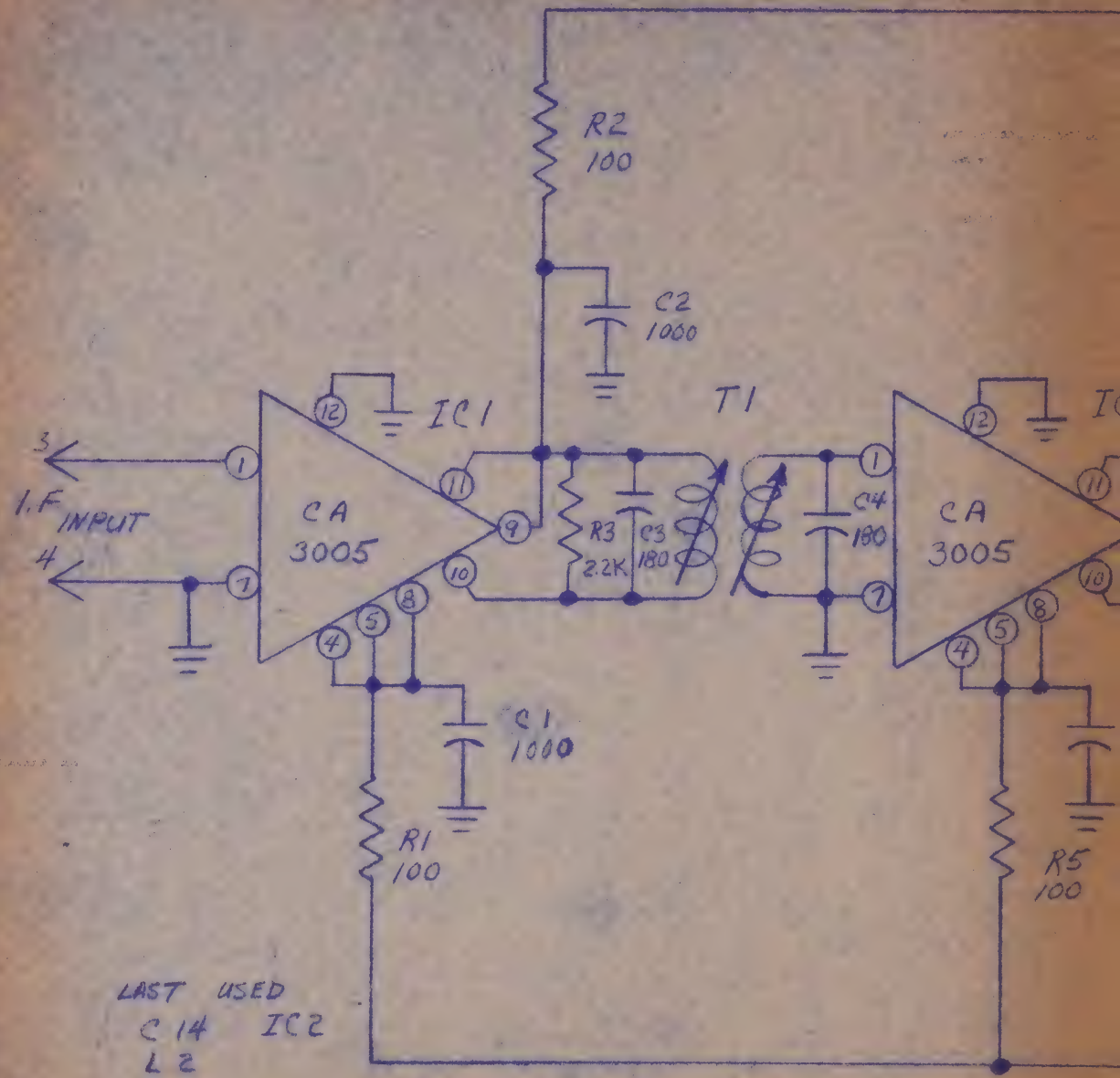
R2
100
C2
1000
IC1
T1
3
I.F INPUT
4
CA
3005
R3
2.2K
C3
180
C4
180
CA
3005
C1
1000
R1
100
R5
100
LAST USED
C 14
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Q 1
R 8
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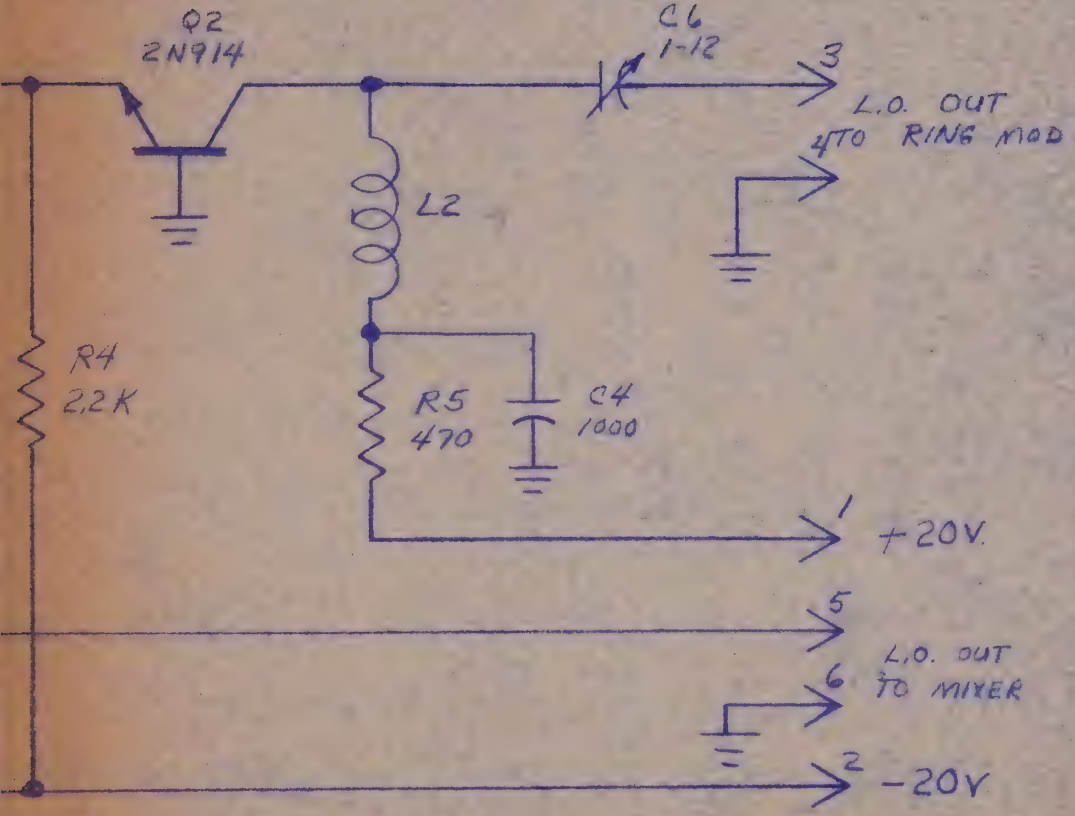
CR 4
IC 2
ALL CAPACITOR VALUES IN pf

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A2 BOARD (XTAL OSC.)

RFA-1

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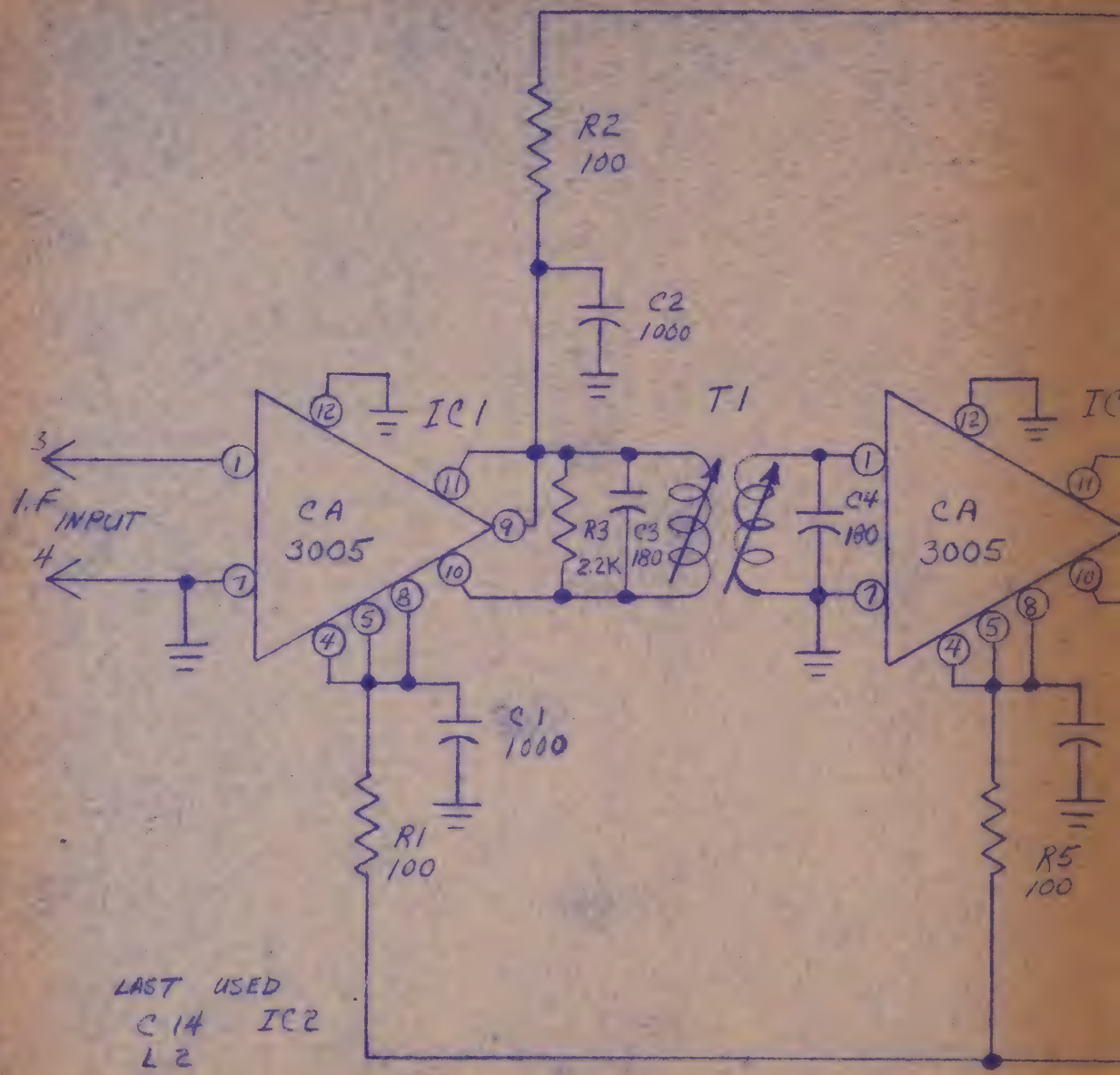
R2
100
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IC1
T1
3
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4
CA
3005
R3
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C4
180
CA
3005
C1
1000
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R5
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LAST USED
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Q 1
R 8
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CR 4
IC2
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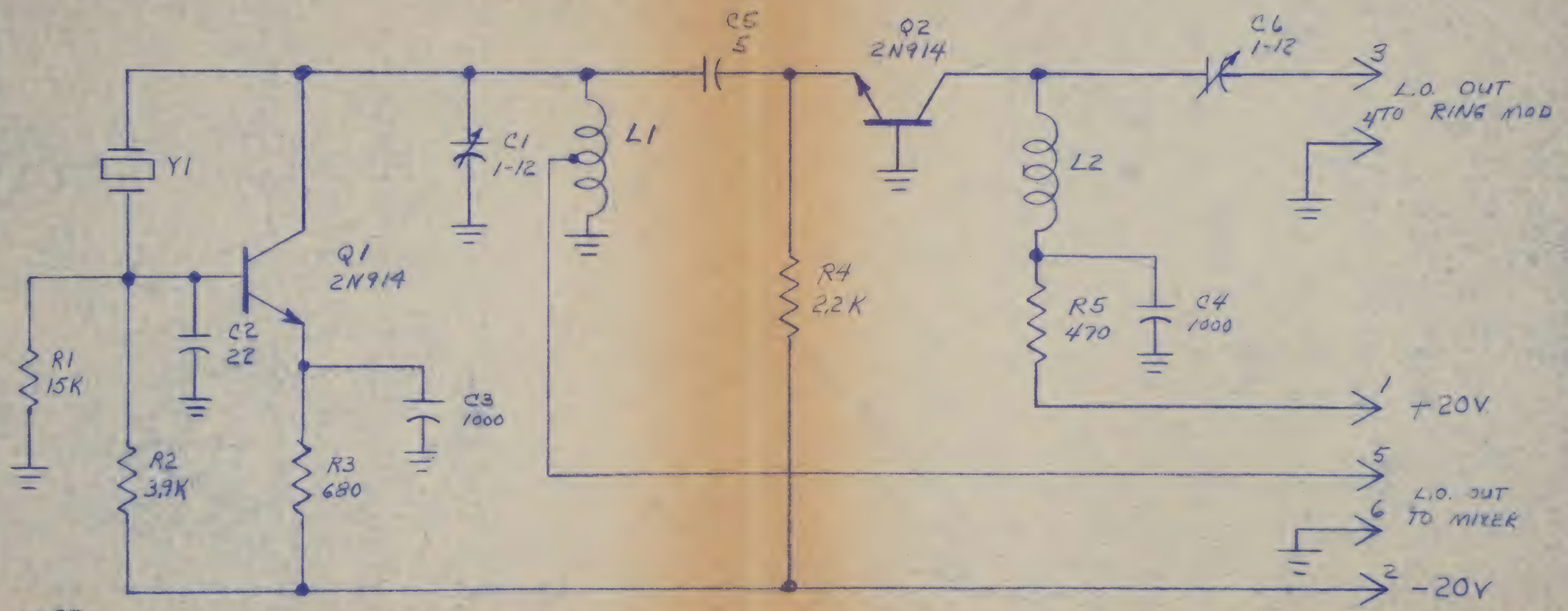


LAST USED
C6
L2
Q2
R5
Y1

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# A2 BOARD (XTAL OSC.)

RFA-1

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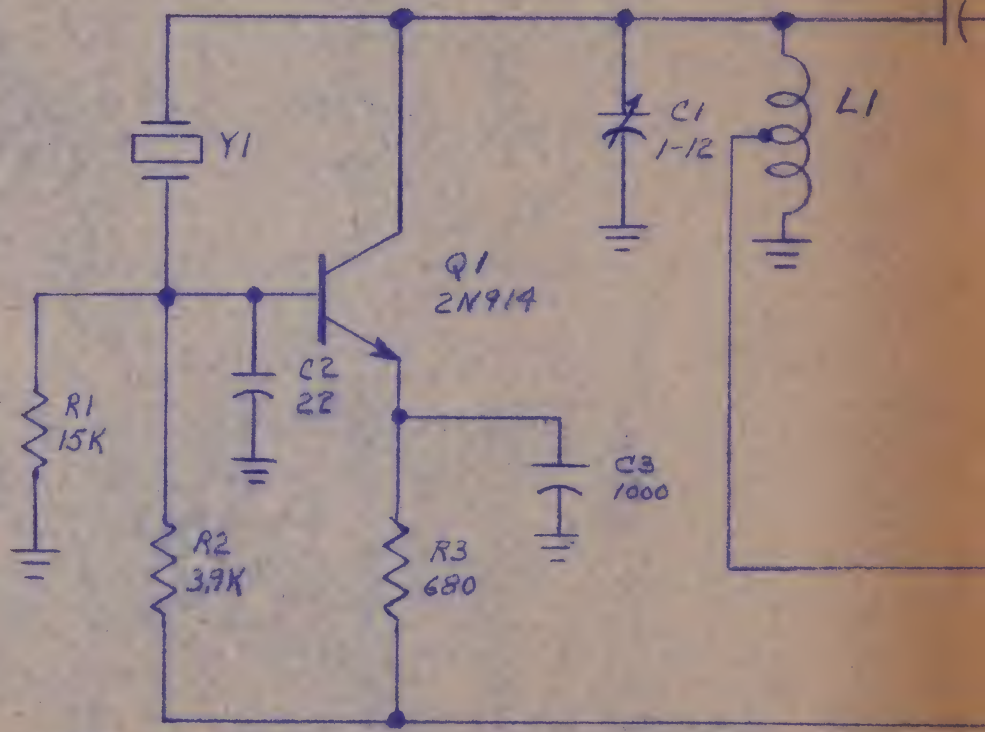


LAST USED

C6
L2
Q2
R5
Y1

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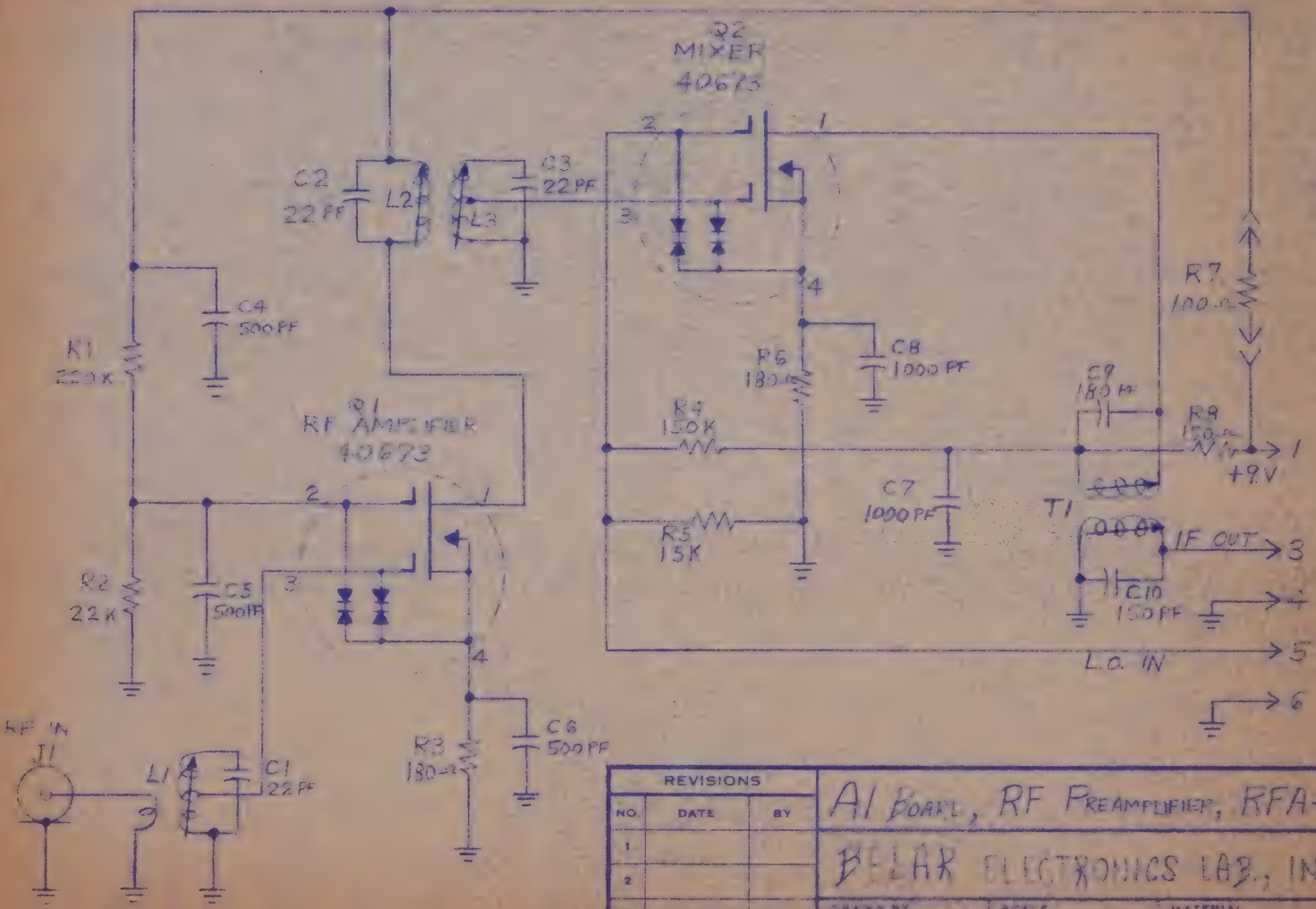


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A1 BOARD, RF PREAMPLIFIER, RFA-1

BELAR ELECTRONICS LAB., INC.

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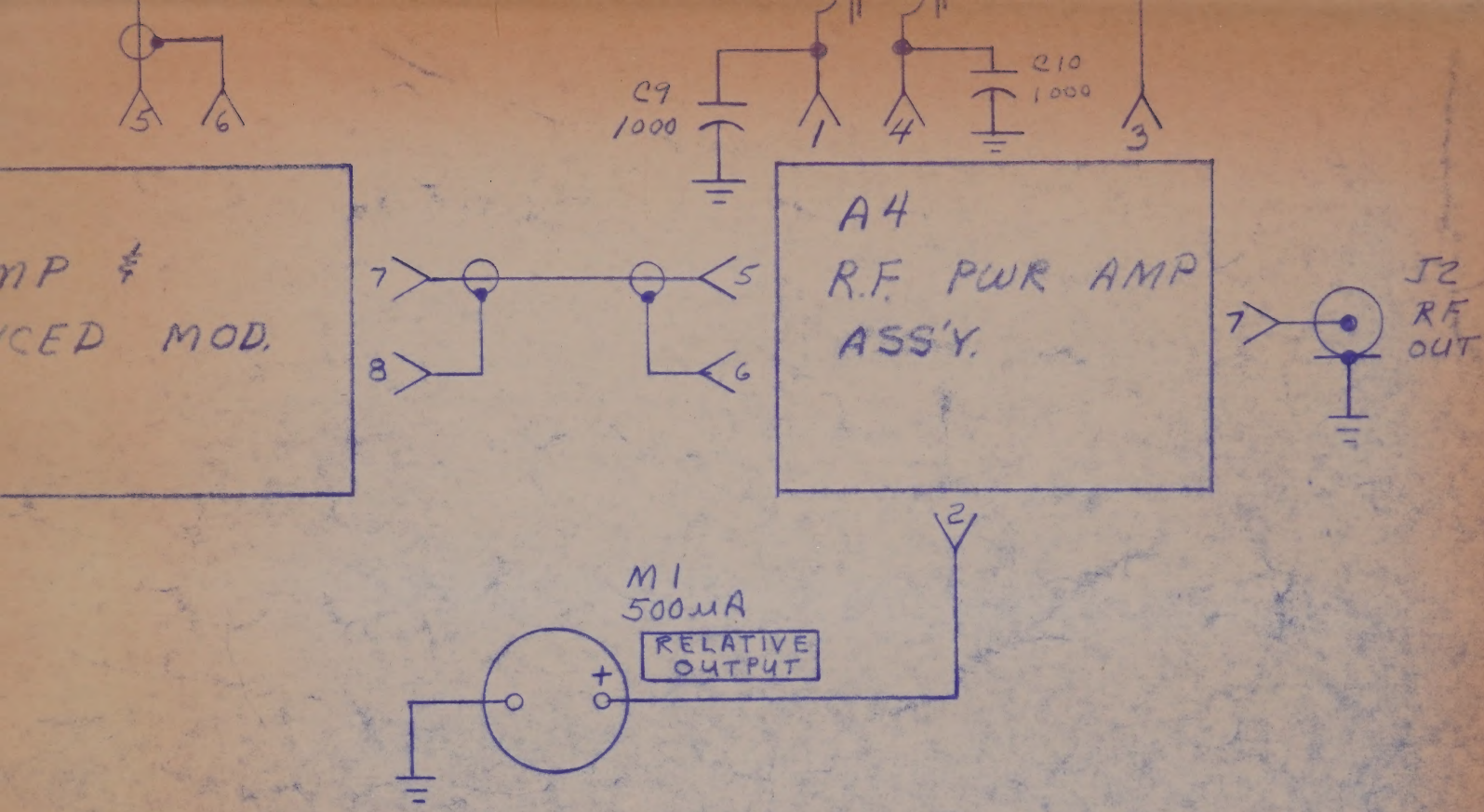


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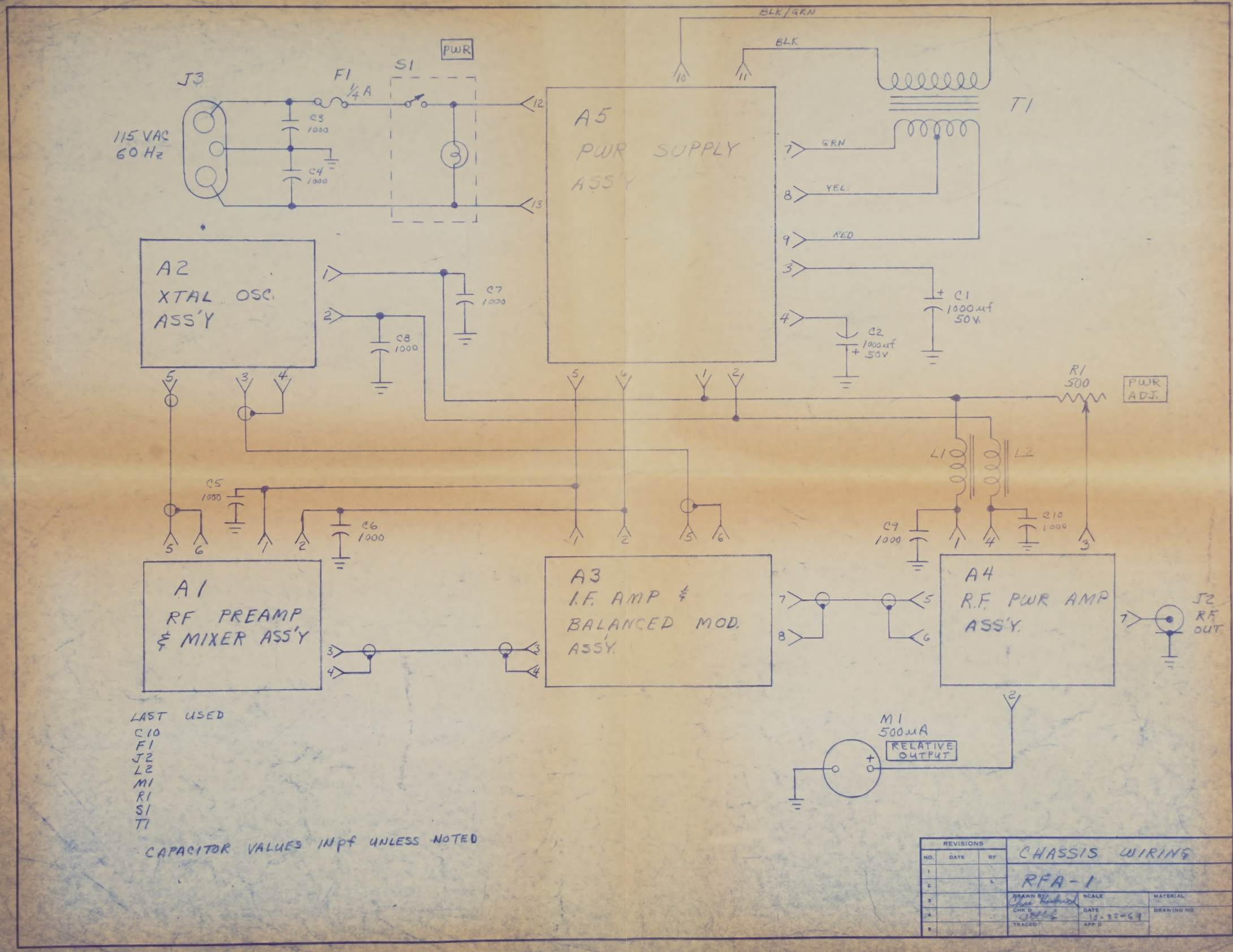


LAST USED

C10
F1
J2
L2
M1
R1
S1
T1

CAPACITOR VALUES IN pf UNLESS NOTED

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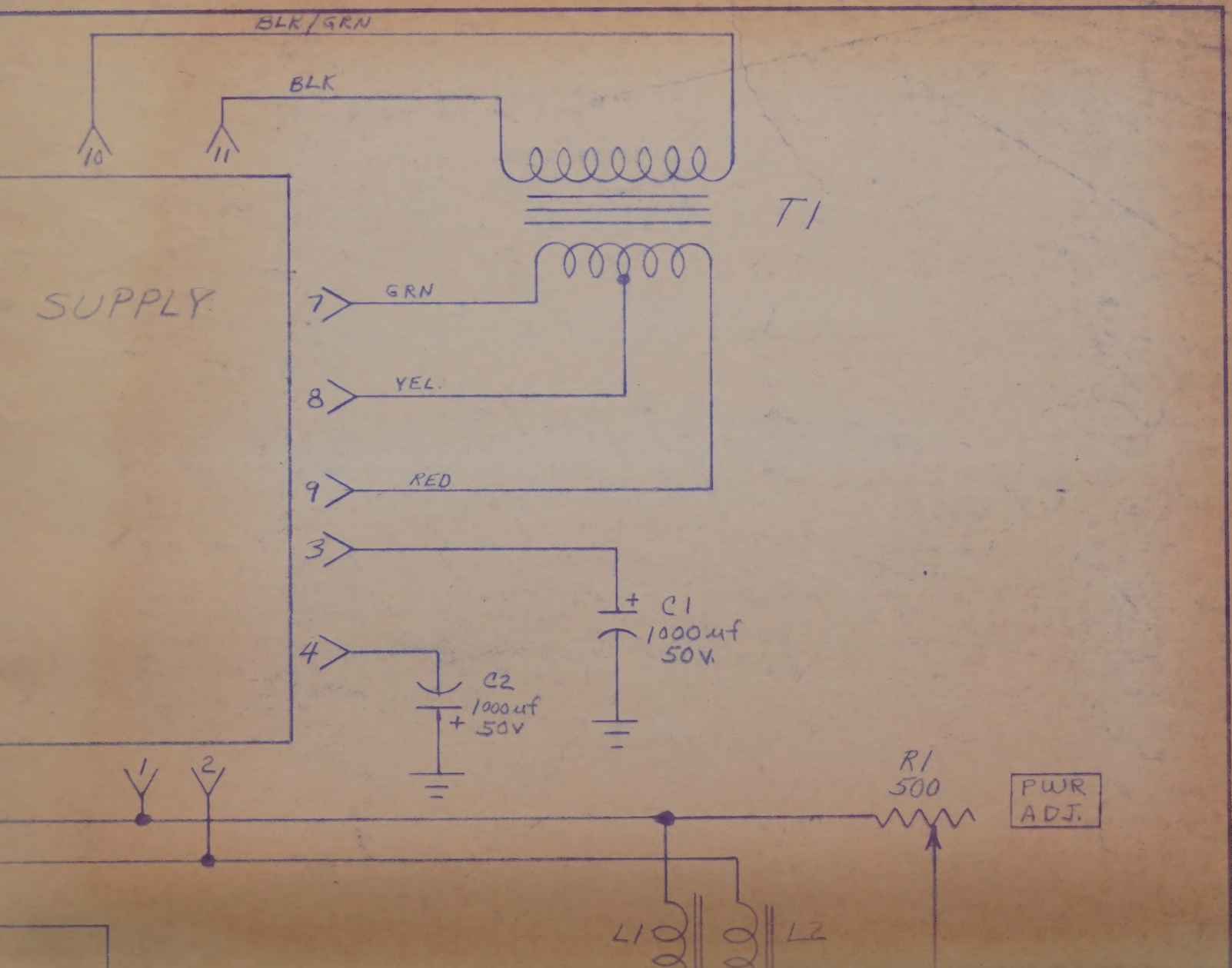
BLK/GRN
BLK
10
11
T1
SUPPLY
7
GRN
8
YEL.
9
RED
3
4
+ C1
1000 uf
50V.
C2
1000 uf
+ 50V
1
2
R1
500
PWR
ADJ.
L1
L2